ADMIN. 1000A (REV. 8/76)

STATE OF MINNESOTA

Office Memorandum

DEPARTMENT Health

TO : Jim Pankanin (5E-WHME)
U.S. Environmental Protection Agency
Water & Hazardous Materials Enforcement
230 S. Dearborn Street
Chicago, Illinois 60604

DATE: 9/18/81

FROM : Michael Convery

PHONE: 612-296-5297

SUBJECT: Hickok Reports G18-7 and G18-11.

I am forwarding to you for your information and review copies of Hickok reports G18-7 and G18-11. Please return any comments to me by Monday-noon - September 28.

545 Indian Mound
Wayzata, Minnesota 55391

(612) 473-4224

September 15, 1981

Mr. Michael Convery
Minnesota Department of Health
717 SE Delaware Street
Minneapolis, Minnesota 55440

Re: St. Louis Park Groundwater Contamination Study

Dear Mike:

Enclosed are memorandums Numbers G18-7 ("Contaminated Soils Management") and G18-11 ("Supplemental Testing, Bench Scale and Pilot Test Programs") for the referenced project.

Respectfully submitted,

EUGENE A. HICKOK AND ASSOCIATES

E. A. Hickok

E. A. Hickok, P.E.

bt

Enclosures

cc: Richard Ferguson, MPCA
Marc Hult, USGS

SEPTEMBER 9, 1981

ST. LOUIS PARK GROUND WATER CONTAMINATION STUDY-
SUPPLEMENTAL TESTING, BENCH SCALE AND PILOT
TEST PROGRAMS

A SUPPLEMENTAL TESTING AND PILOT TEST PROGRAM IS NECESSARY IN ORDER TO FURTHER CHARACTERIZE EXPECTED WATER QUALITIES FROM A GRANULAR ACTIVATED CARBON TREATMENT FACILITY. WHILE GAC PILOT PLANT STUDIES SUGGEST FAVORABLE PAH REMOVAL FROM THE CONTAMINATED GROUND WATER, FURTHER PILOT PLANT STUDIES ARE REQUIRED BEFORE ANY PRELIMINARY DESIGN CONSIDERATIONS CAN BE INITIATED. THIS MEMORANDUM SUMMARIZES SUPPLEMENTAL TESTING, BENCH SCALE AND PILOT TEST PROGRAM WHICH IS ESSENTIAL AND REPRESENTS COMPLETION OF TASKS 4020, 4070 and 4090.

INTRODUCTION

Activated carbon has been used to purify, decolorize and upgrade the quality of drinking water. Sometimes, activated carbon is used early in a treatment process to remove gross quantities of a contaminant. In other instances, it has been used as a final step for improving water quality by removing trace contaminants. In no case, however, has activated carbon been used solely for PAH removal.

Both powdered and granular carbon have been used in the past for treatment, however, the trend has been to use GAC in lieu of PAC for the following reasons:

1. Decreasing price differential between the two carbons;
2. Problems with disposal of powdered carbon and backwash water;
3. Lack of thermal reactivating system for powdered carbon;
4. Greater labor requirement for powdered carbon system;
5. Higher product losses per weight of carbon used; and
6. Inefficient use of the carbon.

Therefore, this memorandum addresses the supplemental testing, bench scale and pilot plant program related solely to the use of granular activated carbon.

With present technology, it is not possible to predict, on a theoretical basis, how effective a given granular activated carbon will be on a given water or its effectiveness in removing a particular contaminant.

The pilot plant study completed in April 1081 by E. A. Hickok and Associates for the City of St. Louis Park was a minimal effort in determining how effective a specific GAC was in removing PAH compounds. The equipment used consisted of three (3) carbon columns operating in series. A schematic diagram of the system used is shown in Figure 1.

Each 20-inch diameter column consisted of 48 inches of granular activated carbon providing a surface area of 2.17 sq ft and 12.0 lineal feet of carbon. The carbon used in the columns was Nuchar WV-W (12 x 40) with an effective size of 0.87 mm and a uniformity coefficient of 1.49.

Four separate tests were performed at flow rates of 4, 8, 12 and 16 gallons per minute per square foot of filter area. A summary of the individual test was as follows:

	GAC-1	GAC-2	GAC-3	GAC-4
Hydraulic loading (gpm/ft^2)	4	8	12	16
Flow rate (gpm)	8.72	17.44	26.16	34.88
Empty bed contact time (min)	22.47	11.25	7.5	5.6
Linear velocity (ft/min)	0.53	1.07	1.60	2.13

The tests were run at the rates indicated and were run for 24 continuous hours.

While the results (PAH removal) were encouraging, particularly for GAC-1 and GAC-2, the obvious shortcomings were 1) only one type of carbon was run and 2) short operating periods were performed. The end result is that there is insufficient data available to predict long-term PAH removal efficiency and the period of time before breakthrough occurs. Therefore, it is essential to conduct laboratory tests and pilot plant tests to determine such things as:

1. to what extent removal of the contaminant is possible;
2. carbon dosage, i.e., g carbon/g of liquid;
3. Amount of carbon required to be on stream to efficiently remove the adsorbate;
4. effect of linear velocity or flow rate and superficial contact time on performance of the carbon;
5. type of system to install, i.e., series or in parallel; and
6. effect of temperature and/or pH on the adsorptive capacity.

SUGGESTED SUPPLEMENTAL TESTING, BENCH SCALE AND PILOT TEST PROGRAM

The suggested supplemental testing, bench scale and pilot test program would consist of two parts. First, preliminary isotherm tests should be performed to demonstrate the feasibility of a particular granular carbon treatment. Second, pilot plant tests should be conducted to obtain data to be used in designing a full-scale plant.

Laboratory work would consist of tests to determine or verify the following:

1. isotherm tests;
2. carbon dosage;
3. effect of contact time;
4. effect of linear flow velocity;
5. effect of pH;
6. effect of temperature;
7. particle size;
8. adsorptive capacity; and
9. type of carbon to use.

Based on the results obtained in the laboratory, a series of pilot plant tests would be performed to further verify the use of GAC for the removal of PAH contaminants. Each pilot plant test would be run for 240 continuous hours and samples taken for analysis at the following time interval:

Sample Schedule

Raw Water	Treated Water
0	12 hrs
30 min	24
1 hr	36
12	48
24	60
36	72
48	96
60	108
72	120
96	144
120	168
144	192
168	216
192	240 hrs
240 hrs	

The existing carbon columns will be used for the pilot plant tests. Prior to any pilot plant tests as well as laboratory tests, it is suggested that an organizational meeting be held with the Minnesota Department of Health and EPA to review the "state-of-the-art" and verify equipment selection and/or operational scheme.

G18-7

SEPTEMBER 15, 1981

ST. LOUIS PARK GROUNDWATER CONTAMINATION STUDY - CONTAMINATED SOILS MANAGEMENT

THIS MEMORANDUM EVALUATES ALTERNATIVES FOR MANAGING CONTAMINATED SOIL IN THE VICINITY OF THE FORMER REPUBLIC CREOSOTING SITE IN ST. LOUIS PARK, MINNESOTA. PEAT DEPOSITS SOUTH OF THE SITE ARE IDENTIFIED AS PROBABLE CONTINUING "SOURCES" OF GROUNDWATER CONTAMINATION. IT IS RECOMMENDED TO CAP THE PEAT WITH CLAY OR OTHER IMPERMEABLE MATERIAL. PRESENT KNOWLEDGE INDICATES EXCAVATION OF THE PEAT WOULD NOT SIGNIFICANTLY BENEFIT GROUNDWATER QUALITY, BECAUSE OF THE EXISTING EXTENT AND SLOW RATE OF MOVEMENT OF POLYNUCLEAR AROMATIC HYDROCARBONS (PAH) IN THE DRIFT. THIS MEMORANDUM REPRESENTS COMPLETION OF TASKS 5020, 5030 AND 5040 OF THE REFERENCED PROJECT.

I. INTRODUCTION

This memorandum evaluates alternatives for managing contaminated soil in the vicinity of the former Republic Creosoting site in St. Louis Park, Minnesota. It is an extension of the memorandum issued March 12, 1981, entitled, "Alternatives for Contaminated Soil Management." In this memorandum, the soils are taken to include all unconsolidated materials overlying the bedrock. The contaminants of primary concern are polynuclear aromatic hydrocarbon (PAH) compounds.

The present analysis does not address the question of whether removing or treating the contaminated soil would beneficially affect the groundwater quality; rather, it assumes this to be the case. This question is discussed in the documentation of gradient control wells, comprising a separate part of this project. The analysis of soil management alternatives also assumes that gradient control wells will in fact operate in the shallow aquifer.

The plan of this memorandum is to discuss the extent of soil contamination, evaluate and select alternatives for managing the contaminated soil and estimate the costs of the selected alternatives.

II. CONCLUSIONS

The following conclusions are based on information available as of August 1981.

1. PAH contamination in the soil (which here includes all material above bedrock) occurs in an area including the Republic site and extending approximately one mile east and one-half mile south of the site.

2. Available data are inadequate to define the full extent of PAH contamiantion in the soil or whether the contamination is continuous in the area cited above.

3. Surficial peat deposits south of the site probably act as continuing "sources" of groundwater contamination in the drift, based on indirect information. what's this?

4. Available data do not define the full extent of peat deposits at the south of the site, nor is any measurement available of PAH concentration in the peat or the groundwater in contact with the peat.

5. Four soil management alternatives are selected for further consideration, namely 1) capping with clay or other low-permeability material, 2) excavation and disposal at a secure landfill, 3) excavation and disposal by land spreading, and 4) excavation and incineration.

6. Based on current knowledge of PAH sorption, it appears that removal of the "source" peat deposits would <u>not</u> beneficially affect groundwater quality in the drift, because of the extremely slow rate of movement expected for contamination already in the drift.

III. RECOMMENDATIONS

The following recommendations rest upon information available as of August 1981.

1. The "source" peat deposits south of the site should be capped with clay or other low-permeability material to provide for maximum surface water runoff.

2. Prior to capping, a systematic field investigation should be carried out to define the full extent of the peat and the pattern and concentrations of PAH in it.

3. The potential groundwater quality benefits of removing the peat deposits should be re-evaluated as new information on PAH sorption becomes available.

4. The Minnesota Department of Health, Minnesota Pollution Control Agency and City of St. Louis Park should communicate with the Minnesota Hazardous Waste Board regarding the possible disposal of PAH-contaminated soils at a future secure landfill, in case removal later appears beneficial to the groundwater.

5. Land spreading and incineration data specific to the locale and the contaminated soil characteristics should be sought, in case removal later appears beneficial to the groundwater.

IV. EXTENT OF CONTAMINATION

Monitoring of groundwater and soil in the vicinity of the former Republic Creosoting site indicates contamination of the soil with creosote-related compounds. For purposes of this memorandum, the soil is taken to include all unconsolidated material overlying the bedrock. Soil on and near the Republic site includes near-surface peat deposits and/or fill throughout much of the area, with the underlying material predominantly sand with clay layers.

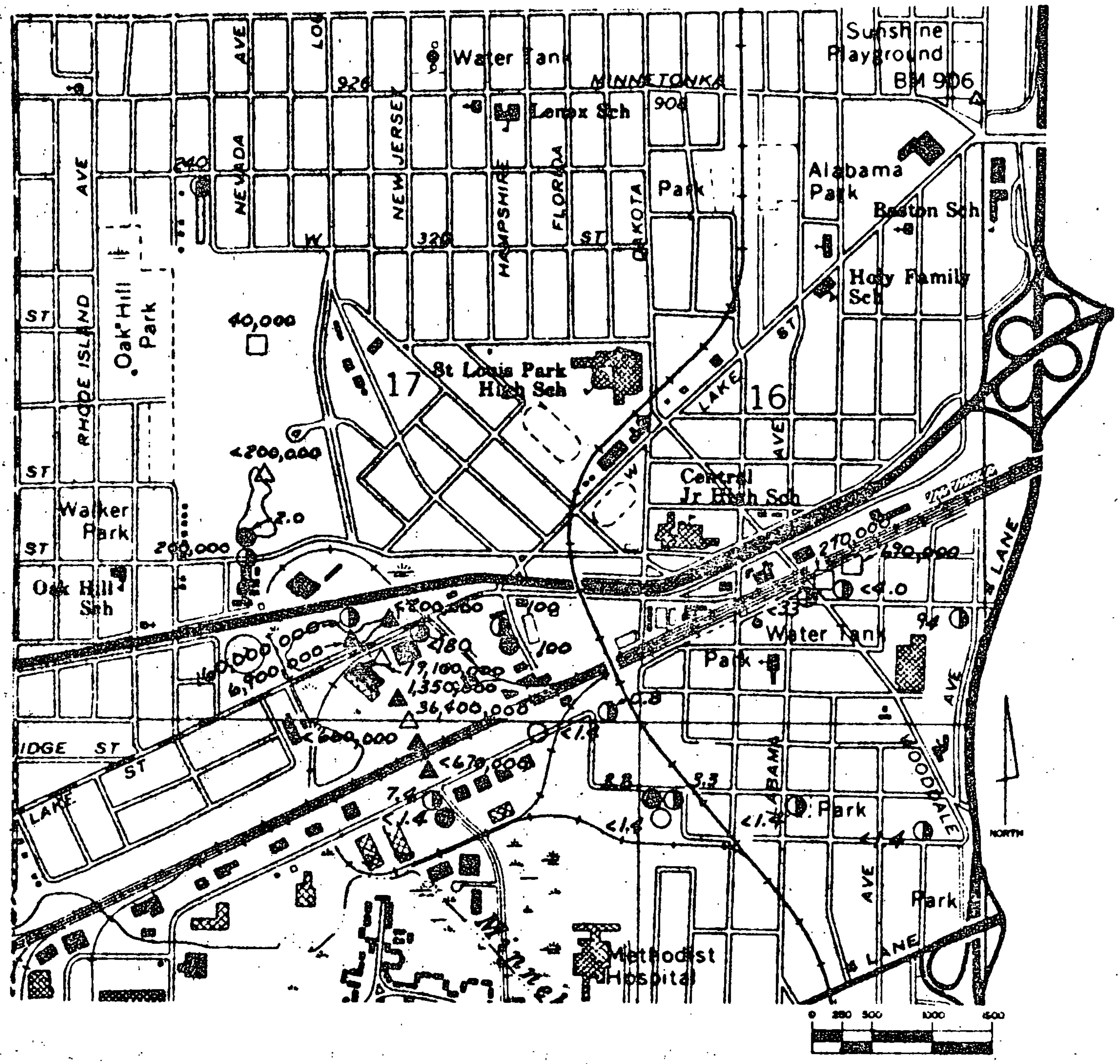
The primary indicators of contamination are considered to be polynuclear aromatic hydrocarbons (PAH). PAH are important constituents of creosote and the raw and intermediate products from which creosote derive. Approximately a dozen PAH compounds are known to be carcinogenic. Recent years have seen advances in measurement techniques for PAH; formerly, attention focused on other parameters as indicators of creosote contamination.

In an earlier report (Barr Engineering Co., 1977), the parameters phenol and "benzene extractable" form the basis for estimating the extent of contamination in the vicinity of the site. The volume of contaminated soil, measured from figures in the referenced report, is approximately 1,600,000 cubic yards (for benzene extractable >1,000 ng/kg) or 2,500,000 cubic yards (for phenol >1 mg/kg). These estimates entail contamination at soil depths as great as 60 feet in some locations. The soil borings on which these estimates rely were on the site or in the immediate vicinity, the most distant boring being 2,000 feet east of the site. The concentration limits used for the volume estimates have no defined public health significance, but were arbitrarily considered in the referenced report.

The above-cited 1977 report also includes some PAH measurements. More extensive PAH data have been obtained since 1977 for soil borings along the recent Louisiana Avenue extension, a 1980 soil investigation by MPCA at 36th Street and Wooddale Avenue, and groundwater monitoring throughout the area conducted by the U.S. Geological Survey in cooperation with the Minnesota Department of Health and others. The PAH data directly concern public health.

The memorandum entitled "Literature Review - Acceptable Contaminated Levels" proposes PAH criteria for groundwater. The proposed maximum levels are 2.8 ng/l for each PAH known to be carcinogenic and 28.0 ng/l for other PAH compounds individually. The memorandum also proposes that soil criteria derive from the groundwater criteria by means of a "sorption factor," or partition coefficient. On this basis, the soil is contaminated (i.e., violates the criteria) wherever the groundwater is contaminated, and vice versa. A "sorption factor" of 500 liters/kg was suggested in the cited memorandum. However, analysis of literature information indicates lower values are appropriate for the sandy Middle Drift stratum. Generally, appropriate values here appear to be 100 liters/kg for the more complex carcinogenic PAH and 10 liters/kg for other PAH. These lead to soil criteria of 280 ng/kg in the drift for individual PAH compounds, whether carcinogenic or not.

Soil and groundwater PAH data from the sources cited above are mapped on Figure 1 - Soil Contamination in Vicinity of Former Republic Creosoting Site. Data shown are benzo(a)pyrene concentrations in units equivalent to parts per trillion for both



LEGEND

SOIL BORINGS:

- □ UNSATURATED
- △ SATURATED, DEPTH < 20FT.
- ▲ SATURATED, DEPTH > 20FT.

MONITORED WELLS:

- ○ WATER TABLE
- ◐ MIDDLE DRIFT
- BASAL DRIFT

NOTE:
NUMBERS ARE BENZO(a)PYRENE CONCENTRATIONS IN ng/kg (SOIL) OR ng/l (WELL)
SHOWN ARE MOST RECENT DATA AS OF AUGUST 1981

FIGURE 1

SOIL CONTAMINATION IN VICINITY OF FORMER REPUBLIC CREOSOTING SITE soil and groundwater. Benzo(a)pyrene was chosen as an indicator because its data are most extensive and it is strongly carcinogenic.

Figure 1 shows soil contamination at locations north and south and as far as one mile east of the site, as well as on the site itself. The extent of contamination is not fully defined because nearly all monitored locations exhibit elevated benzo(a)pyrene levels.

Whether or not contamination is continuous between monitored points is not known. Evidence exists for local sources of PAH separate from the Republic site itself. For example, the MPCA soil investigation at 36th and Wooddale revealed a pattern indicative of a local spill at that location. (The spilled material could plausibly be creosote - because the location is on the same railroad line which formerly served the Republic Creosoting plant - or material used by the neighboring D and A Lubricant Company, or material from some other source.) Another location which appears to be separately contaminated is near 31st Street and Oregon Avenue, which is north of the site. It appears very unlikely that PAH contaminants have migrated from the site to either of these two locations by way of groundwater flow. Thus, there are probably several separate zones of contamiantion in the soil.

To sum up, PAH contamination of the soil (which, once again, here includes all material above bedrock) occurs in an area including the Republic Creosoting site, and extending approximately one mile east and one-half mile south of the site. The contaminated soil zone may extend beyond this area, but no data are available to support or deny this. Also, it is probable that the contamination is not continuous within the area described.

Evidence suggests that peat deposits on and near the site behave as continuing sources of groundwater contamination. Liquid waste disposal into wetland areas south of the Republic site was documented as early as 1938 (Kampo, 1938), and still occurred in the final years of plant operation (Hickok and Associates, 1969). This introduced a substantial amount of contaminants into the wetland peat deposits. At the same time peat, because of its high organic carbon content, is expected to be strongly adsorptive of PAH. In fact, J. C. Means and co-workers have demonstrated that PAH adsorption in a variety of soils is proportional to organic carbon content (Means *et al.*, 1979; Means *et al.*, 1980). On this basis, adsorption in the peat deposits is probably one or more orders of magnitude greater than in the sandy drift underlying the peat in the vicinity of the Republic site. The underlying Middle Drift aquifer exhibits its highest PAH concentrations at the same location as the wetland south of the site. As of August 1981 there are no PAH data available for the peat itself or the water in the peat. However, all of the above considerations implicate the peat deposits as highly contaminated zones which continue to act as sources of groundwater contamination.

If excavation or treatment of soils in the Republic site vicinity is to be implemented to remedy contamination, then highly contaminated peat deposits are the logical soils to manage. The wetland peat deposits south of the site extend to a maximum depth of approximately 27 feet in some lcoations between Highway 7 and Lake Street (based on soil boring data in Barr, 1977). A few borings north of Highway 7 indicate shallower peat deposits there than between Highway 7 and Lake Street. As an approximate gross estimate, the peat deposits south of the site are considered to cover 15 acres with an average depth between 15 and 20 feet. The estimated volume is then approximately 400,000 cubic yards.

It is emphasized that there are no PAH data for the peat deposits, nor have the existing soil borings fully delineated the peat deposits themselves. Definition of the contamination pattern and concentration levels in the peat deposits, and of the extent of the peat, will require systematic field investigations. The above estimates of 15 acres and 400,000 cubic yards wil be used for cost estimating and other purposes in this memorandum.

V. SELECTION OF ALTERNATIVE METHODS

A. Identification of Methods

The March 12, 1981 memorandum[1] listed thirteen alternative methods for handling the PAH contaminated soil in the vicinity of the site. The list is provided so that a wide range of available methods might be considered. The treatment methods fall into the following groupings:

- No action;
- Surface treatment: capping;
- In-place treatment: solidification, fixation/ stabilization; and
- Excavation: secure landfill, encapsulation or containerization with landfill, land spreading, resource recovery as-is, modification and warehousing, resource recovery, admixing and incineration.

This discussion of soil management methods assumes that gradient control wells will be used in the drift.

B. Evaluation of Methods

The twelve methods listed above are reviewed and evaluated in the following paragraphs.

1. No Action

a. Method

One option is to do nothing and leave the soils in place. With extended time, flushing would occur and the impact of the source material would be lessened.

b. Practical Implementation

The no action alternative is currently implemented.

c. Treatment Effectiveness

This alternative provides no treatment for the contaminated soils other than dilution of the contaminants afforded by groundwater flow.

d. Environmental Effectiveness

This option does ot present any significant immediate environmental advantages and will likely result in continuous long-term adverse effects on the groundwater.

e. Evaluation

Based on the lack of treatment effectiveness and the continued long-term adverse effects on the groundwater resource, this alternative is not recommended.

2. Capping

a. Method

This action leaves the contaminated soil in place and covers area of contamination with compact clay or other impermeable cover. The impermeable cap serves to minimize infiltration of precipitation. The site under this option would also be graded in order to minimize surface runoff impacts and to further reduce opportunities for infiltration.

b. Practical Implementation

Under the capping alternative, cover material could be placed over the contaminated soil and grading could be accomplished using conventional construction methods. This action requires continuing maintenance of the cap and monitoring to assure the cap's integrity.

c. Treatment Effectiveness

The capping alternative provides no treatment for the contaminated soils. As in the case of no action, groundwater flow slowly dilutes contaminants in the soil under the cap. However, the dilution is somewhat lessened with a cap due to the prevention of infiltration.

d. Environmental Effectiveness

Capping reduces infiltration and hence total groundwater flow through the contaminated soil. This results in slower flushing of the source material, which somewhat mitigates the downgradient groundwater impacts while retaining higher contaminant levels in the soil itself. Capping would also prevent direct skin contact with the contaminated soil.

e. Evaluation

The capping alternative by itself is not a complete, long-term solution for contaminated soils. However, it has significant environmental benefits and is attractive as an interim measure or, perhaps, as a long-term solution in combination with gradient control wells.

3. Solidification

a. Method

Soil contaminated with certain materials can be bound in a solid form by injection of chemical agents in-place or by excavation, processing and replacement of the processed soil, either on-site or off-site. In this manner, the surface area of the contaminated material is reduced and the low permeability of the resultant solid prevents rapid leaching of contaminants (Pojasek, 1978).

b. Practical Implementation

A wide variety of solidification agents that have been used for hazardous wastes, including portland cement, urea-formaldehyde, asphalt, pozzolanic cements, polybutadiene silicates, sulphur foams, soil binding agents and ion exchange resins. However, there are difficulties with compatibility of organic chemicals with the solidifying agents, and solidification of creosote contaminants apparently has not been tried. This makes implementation of this alternative questionable.

c. Treatment Effectiveness

The solidification of contaminated material aims to reduce leaching of the contaminants. However, the effectiveness for PAH compounds is not known.

d. Environmental Effectiveness

The effectiveness of solidification for PAH-contaminated soil is questionable, as noted above. In addition, some solidification agents may themselves be considered potential contaminants and would need to be assessed accordingly. This method, if proved effective, has the potential advantage of allowing redeposition on-site, so that transportation hazards would be minimized.

e. Evaluation

Solidification is not recommended because of its questionable effectiveness for soil contaminated with PAH compounds.

4. Fixation/Stabilization

a. Method

Fixation of contaminated material is accomplished by mixing in additives to modify the material's chemical and physical properties. Chemical fixation may alter the concentration of a particular contaminant or affect solubility in a variety of ways, including altering the pH or complexing or sequestering the contaminants in a matrix provided by the additive (Landreth, 1977). This method is similar to solidification, except the treated material is not necessarily cohesive and rigid.

b. Practical Implementation

Fixation/stabilization has the same difficulties with organic chemical compatibility as solidification.

c. Treatment Effectiveness

Fixation/stabilization has approximately the same treatment effectiveness as solidification.

d. Environmental Effectiveness

Fixation/stabilization has approximately the same environmental effectiveness as solidification.

e. Evaluation

Fixation/stabilization is not recommended for the same reason as solidification.

5. Secure Landfill

a. Method

The secure landfill alternative entails excavating the contaminated soil in a non-consolidated form and transporting it to a secure facility. A secure landfill is an ultimate disposal site specifically designed to contain hazardous wastes and minimize environmental contamination (Pojasek, 1978). A secure landfill generally has impermeable lining and a leachate collection system, surface runoff diversion and an ultimate closure plan. A properly designed facility also includes facilities for groundwater and surface water monitoring and evaluation. Excavation of soils from the Republic site vicinity would also entail backfilling with clean fill, such as washed sand. The excavation would be wet, and the fluid encountered would likely require truck or rail transport to an ultimate disposal site.

b. Practical Implementation

Contaminated soils can be removed from the site vicinity using standard excavation techniques such as backhoe or drag line. For contaminated soils below the water table, it may be possible to use a hydraulic dredge. Excavated and dredged material would require draining prior to transport to reduce volume and minimize spillage hazards. Disposal of the drained fluid poses a special difficulty. Great care would be required in the transport of the contaminated soil.

The finding of a secure landfill facility to accept the contaminated soils may pose a considerable problem. It is anticipated that an out-of-state secure landfill would not accept 400,000 cubic yards of contaminated soils. According to the State of Minnesota's 1980 Waste Management Act, the necessary permits for a secure landfill here will not be obtained until 1983, and the construction of such a landfill would not be completed until several years later.

c. Treatment Effectiveness

The secure landfill alternative does not include treatment of the contaminated soil.

d. Environmental Effectiveness

The removal of the contaminated soil material from the site and its replacement with clean fill will effectively eliminate the source of continuing groundwater contamination. Transportation of the contaminated soil has potential negative environmental impacts due to the hazard of spills. Once at the secure landfill, by nature of its design and monitoring provisions, the environmental impact of the contaminated soil disposal will be minimal.

e. Evaluation

The secure landfill is today a well-tried and reliable method for disposal. Although excavation near the Republic site would entail special problems with liquid disposal, this alternative shold be further considered. A realistic time for the finding of a disposal site for the contaminated material is between five and seven years. Thus, if excavation and landfilling are to proceed, some additional interim measures would be appropriate at the site.

6. Encapsulation or Containerization with Landfill

a. Method

Encapsulation is the physical process in which an agent surrounds the contaminated particles (Pojasek, 1978). These agents may include chemical compounds as well as physical confinement such as barrels or other containers suitable for long-term storage. Encapsulated or containerized soil contaminated with PAH would probably require a secure landfill for ultimate disposal due to restrictions on the use of ordinary sanitary landfills for such purposes.

b. Practical Implementation

The constraints for the practical implementation of encapsulation or containerization and landfilling would be similar to those for landfilling of non-containerized materials.

c. Treatment Effectiveness

The treatment effectiveness of chemical encapsulation methods is not known for PAH compounds. Other methods of containerization do not entail treatment.

d. Environmental Effectiveness

The removal of waste from the site in an encapsulated or containerized form would have the same positive environmental effects as for non-containerized disposal to a secure landfill. Encapsulation or containerization would also reduce the environmental risk of transportation and may also render the contaminated soil more manageable at the secure landfill site.

e. Evaluation

Hauling contaminated waste in an encapsulated or containerized form would reduce the environmental hazards in moving the contaminated soils. There would, however, be additional cost in containerizing the contaminated soils. The decision whether to remove the contaminated soils in bulk or in encapsulated or containereized form would depend upon the nature and operating constraints of the secure landfill facility used for ultimate disposal.

7. Land Spreading

a. Method

Land spreading, sometimes called land farming, land treatment or soil incorporation, is the controlled disposal of wastes in the surface soil accompanied by continuing monitoring and management of the disposal site (Brown, 1980). This technique often includes crop cultivation on the disposal site. The land spreading alternative requires excavating the contaminated soil in the Republic site vicinity and transporting it to a designated disposal site.

b. Practical Implementation

Land spreading would require the same on-site work and transportation as not the same distance landfilling. The contaminated soil would be spread at a controlled application rate and disked or plowed into the soil on a designated disposal site. Crop cultivation could entail seeding, fertilizing and aerating the soil one or more times per growing season. Crop use would at a minimum require careful chemical monitoring. Special management and monitoring of the disposal site would need to continue for several years, perhaps a decade. A major difficulty with implementing this alternative is acquisition of a disposal site. Spreading 400,000 cubic yards of contaminated soil at a depth of six inches (assuming this permissible) would require 500 acres. A good disposal site would have gentle slopes, moderately well drained soils, and a large depth to water table or bedrock.

c. Treatment Effectiveness

Land spreading has been used by the petroleum industry for the disposal of process sludge. Degradation of oily petroleum sludges by microbial action in cultivated soils has been demonstrated in prevailing soil and climatic conditions at Deere Park, Texas (Kinkannon, 1972). However, residual oil extracted from the soils was characterized by infrared scan to be polyaromatic oils, suggesting that this hydrocarbon group is slowly reactive or nonreactive for microbial decomposition at the prevailing conditions (Ibid.). Dr. K. W. Brown (personal communication, August 25, 1981) has observed that many PAH will degrade in soil, the more complex PAH degrading more slowly and requiring possibly a few years to degrade. Information is needed on the nature of PAH decomposition products and their mobility and biodegradability in the soil. However, it appears that land spreading could provide effective treatment of PAH contaminated soils.

d. Environmental Effectiveness

Land spreading is similar to landfilling in its environmental effectiveness at the original site and in transportation-related hazards. Environmental effects at the disposal site would be carefully managed and monitored and would persist for relatively few years.

e. Evaluation

Land spreading appears to have potential as an effective means of ultimate disposal for PAH-contaminated soils and should be further considered. It is recommended that further information specific to land spreading of PAH-contaminated soils in the Minnesota climatic regions be sought. Because several years may be needed to select and acquire a disposal site, interim measures in the Republic site vicinity would also be appropriate.

8. Resource Recovery As-Is

a. Method

It has been suggested that sandy soil contaminated with PAH might be useful for construction of secondary rural roads or as a sub-base medium beneath asphalt or other roads (Hite, 1981). This would be course entail excavation at the contaminated site. Since it is contaminated peat soils, rather than sandy soils, which are identified for special management, this alternative is not appropriate.

b. Practical Implementation

This alternative is not practical for peat soils.

c. Treatment Effectiveness

There is no treatment with this alternative.

d. Environmental Effectiveness

This alternative is not effective or practical.

e. Evaluation

This alternative is not recommended.

9. Modification and Resource Recovery

a. Method

Methods of possible hydrocarbon recovery require a modification of the material and include hydrogenation, pyrolysis, flash photolysis, arc image heating, reaction with plasma, laser irradiation, microwave discharge and very rapid pyrolysis.

b. Practical Implementation

These methods are considered experimental for this scale of application.

c. Treatment Effectiveness

Given the experimental nature of these treatment schemes, the treatment effectiveness is unknown.

d. Environmental Effectiveness

Given the experimental nature of these methods, their environmental effectiveness is not known.

e. Evaluation

None of these methods are recommended at this time.

10. Warehousing

a. Method

Warehousing is a form of engineered waste storage, the ultimate goal of which is either reclamation or later permanent disposal of the waste material.

b. Practical Implementation

Warehousing would require the same on-site work and transportation as landfilling. The alternative would also require construction of an engineered storage facility providing safe, long-term storage along with retrievability of the contaminated material. The warehouse would need maintenance and monitoring for at least as long as it stores contaminants. Ultimately, the stored material would have to be again transported to final disposal or handled in some other way.

c. Treatment Effectiveness

This method does not include treatment of the contaminated soils.

d. Environmental Effectiveness

Warehousing is similar to landfilling in its enviornmental effectiveness at the original site and in transportation-related hazards. Environmental impacts at the warehouse site would be minimal by nature of the design. However, the ultimate fate of the contaminated material is not specified, so the long-range environmental effectiveness cannot be evaluated at present. In essence, warehousing is deferring the problem for a later solution.

e. Evaluation

Warehousing is not recommended because it does not provide an ultimate disposal solution and yet requires even more substantial efforts than other alternatives which do.

11. Admixing

a. Method

Admixing is a process of adding and blending adsorptive materials with the contaminated soil. This alternative might be appropriate if the contaminated soils identified for special management were sandy soils. However, the identified soils are peat soils, which are inherently adsorptive. This alternative is therefore not appropriate.

b. Practical Implementation

This is not a practical alternative.

c. Treatment Effectiveness

Admixing is not expected to be effective for contaminated peat soils.

d. Environmental Effectiveness

This is not an effective alternative.

e. Evaluation

This alternative is not recommended.

12. Incineration

a. Method

Incineration is recognized as a viable disposal technique for organic hazardous wastes (Benforado, 1977). Under controlled conditions, many organic wastes can be incinerated, producing inert ash and stable oxide forms of the major elemental constituents. This alternative entails excavation of the contaminated soils.

b. Practical Implementation

Incineration would require the same on-site work as landfilling. The contaminated soils could be incinerated either on or off the site. There are several critical factor in the design of an incinerator for a partially combustible waste, such as contaminated soil. First, the waste material must be atomized as finely as possible to present maximum surface area for mixing with combustion air. Second, adequate combustion air must be present to supply all the oxygen required for oxidation of the organics. Third, an auxiliary fuel is required to supply heat sufficent to raise the temperature of the waste and combustion air to a point above ignition temperature of the organic waste. Unlike fully combustible wastes which may be injected through the combuster, contaminated soil would be atomized in a secondary chamber. Temperatures to promote complete combustion of PAH range from 2200° F to 2700° F. At such temperatures it is believed that 97 to 98 percent of organics in the contaminated soils will be destroyed and the byproducts can be vented to the atmosphere (Hillyard, 1981).

There is no operating hazardous waste incineration in the STate of Minnesota. At substantial cost, such an incinerator could be constructed on or off the contaminated site. Another possibility is the use of power plant boilers. Northern States Power Company, with several power plants in the Twin City area, has investigated and reported favorably on the concept of incinerating hazardous wastes in its utility bailers (Banks et al., 1979). However, the power company has not instituted this procedure, nor is it certain that the contamianted soil specifically would be compatible with bailer operation. The Metropolitan Wastewater Treatment Plant has a sludge incinerator, but its operating temperature appears to be too low for incineration of PAH.

c. Treatment Effectiveness

Mr. Ed Hillyard of Rollins Environmental, Deere Park, Texas was contacted relative to the incineration of PAH contaminated organic soil from St. Louis Park (personal communication, August 1981). He indicated that Rollins Environmental has evaluated the use of incineration for several projects with PAH and other long chain hydrocarbons. This company has found that incineration can destroy approximately 97 to 98 percent of the PAH compounds, which has fallen short of the current Federal standard of 99.99+ percent and in all of their applications has not been acceptable (Ibid). They are presently evaluating a similar situation for Black and Veatch and Woodward-Clyde at a Superfund project in Texas. In this case, a polystyrate tar is involved with approximately 300,000 cubic yards of soil.

d. Environmental Effectiveness

Incineration is similar to landfilling in its environmental effectiveness at the original site. Incineration has the potential for venting PAH to the atmosphere if the incinerator malfunctions or is not properly controlled. However, this alternative offers the most complete ultimate disposal option available.

e. Evaluation

It appears from the preliminary evaluation that incineration may be a viable option. It is recommended that the contaminated soil be tested further to examine its combustibility and evaluate the byproducts of combustion. An incinerator for this purpose would probably not be available for several years. Thus interim measures in Republic site vicinity would also be appropriate.

C. Selected Alternatives

Based upon the preceding evaluation of soil disposal and treatment methods, four alternatives are selected for further consideration:

1. Capping the area with clay or other low-permeability material.
2. Excavation of contaminated soil and disposal in a secure landfill.
3. Excavation of contaminated soil and disposal by land spreading.
4. Excavation of contaminated soil and disposal by incineration.

The last three alternatives entail removal of contaminated soil and should be undertaken only if it is determined that substantial environmental benefit would result. In particular, a key question is whether excavation would result in a beneficial reduction in the number of years required for gradient control wells to "clean up" the shallow groundwater. Can Hult's model answer this?

This question is addressed in the documentation of the gradient control well system. Briefly, however, present knowledge indicates that excavating the "source material" (i.e., high contaminated peat soils to the south of the Republic site) would <u>not</u> beneficially reduce the clean up time for the shallow groundwater. This is because sorption in the drift - apart from the peat soils - is anticipated to retard PAH flushing for thousands of years, even assuming excavation of the source material. In connection with the St. Louis Park groundwater contamination, the U.S. Geological Survey is currently conducting research on PAH sorption to augment the rather scant literature on the subject.

Because excavating the contaminated soil appears at present to be of questionable environmental benefit, and because facilities for contaminated soil disposal (secure landfill, land spreading site, or incinerator) are not readily available locally, capping is recommended as an immediate remedial measure. At the same time, it is recommended that the potential benefits of contaminated soil removal be re-evaluated as new information becomes available on PAH sorption.

In addition, it would be prudent for the Minnesota Department of Health, Minnesota Pollution Control Agency and City of St. Louis Park to pursue further the feasibility of the three disposal modes for the excavation alternatives. The above agencies should communicate with the Minnesota Waste Management Board, which is responsible for siting and developing design constraints for a secure landfill and hazardous waste processing facility in the State. Land spreading and incineration data specific to the locale and contaminated soil characteristics should also be obtained.

Finally, a systematic field investigation to determine the extent and degree of contamination of the peat soils to the south of the Republic site is required as part of the implementation of any of the alternatives.

VI. COST ESTIMATES

Cost estimates are presented here for the four alternatives selected in the previous section. Note that the capping alternative is recommended at present. The other three alternatives might be determined to be environmentally beneficial at a future time. All of the cost estimates are necessarily of a preliminary nature. The estimates assume a contaminated soil area of 15 acres and a volume of 400,000 cubic yards, as discussed in section IV. The costs of engineering and requisite field investigations are not included.

A. Capping

Capping the contaminated area is estimated to cost $1,500,000. This estimate assumes capping with 5 feet of compacted clay and grading in order to maximize runoff while minimizing erosion potential.

B. Secure Landfill

The cost of excavating the contaminated soil is estimated to be $2,100,000, and that of backfilling with clean fill $4,000,000. The excavated material would be dewatered on-site prior to loading into trucks for hauling. The above costs do not include disposal of the fluid drained from the contaminated soil.

The transportation costs would be substantial, particularly for out-of-state disposal. For example, transportation to the Waste Management, Inc. secure landfill at Germantown, Wisconsin (700-mile round trip) would cost an estimated $12,000,000. Soil excavation and disposal at the Germantown site would thus cost approximately $18,000,000 <u>exclusive of the disposal fee</u> to Waste Management, Inc.

Construction of a new secure landfill near the Twin City area specifically for the contaminated soil would be more economical. In this case the total cost of excavation and disposal is estimated as $15,000,000, which is less than the Germantown option even excluding the disposal fee there.

C. Land Spreading

Land spreading costs are estimated on the basis of an assumed 500-acre cultivated disposal area. The total cost for this alternative is estimated to be $12,000,000, including land purchase and 10 years of cultivation. Major costs are for excavating and backfilling (same as for the secure landfill alternative) and transportation, estimated to be $3,700,000. The assumed price of land is $3,000 per acre.

D. Incineration

The estimated total cost for excavation and disposal by incineration is $45,000,000 using a newly constructed incinerator, costs for which are highly variable. Final costs estimated at $20,000,000 are included in this estimate, as are the same previously used estimates for excavating and backfilling. But this estimate makes no allowance for the incinerator's value following completion of the soil incineration.

Another alternative is incineration at a Northern States Power Company plant, such as the one in Oak Park Heights. Approximately 5 years would be required to incinerate the contaminated soil at an average feed rate of 350 tons per day. The costs for this option are not available, but Northern States Power Company is currently studying the feasibility of such incineration.

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